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U. S. DEPARTMENT OF AGRICULTURE.

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FARMERS' BULLETIN 314.

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A METHOD OF BREEDING EARLY  
COTTON TO ESCAPE BOLL-  
WEEVIL DAMAGE.

BY

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Collaborating with the Texas Agricultural  
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1908.

## LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,  
BUREAU OF PLANT INDUSTRY,  
OFFICE OF THE CHIEF,  
*Washington, D. C., October 14, 1907.*

SIR: I have the honor to transmit herewith a manuscript entitled "A Method of Breeding Early Cotton to Escape Boll-Weevil Damage," by Mr. R. L. Bennett, a special agent of the Bureau of Plant Industry, collaborating with the Texas Agricultural Experiment Station, and recommend that it be published as a Farmers' Bulletin.

The governing board and officials of the Texas station have given every encouragement to this work, and it is due largely to their support and cooperation that valuable results have been so quickly secured.

The method of seed selection pursued in this collaborative work and described in this paper is especially valuable to the cotton growers in the region invaded by the weevil, as it will enable them to develop by their own efforts rapid-fruited cotton, which is most important in producing a profitable crop.

The directions for seed selection are clearly presented by Mr. Bennett and will be readily understood by growers.

Respectfully,

B. T. GALLOWAY,  
*Chief of Bureau.*

HON. JAMES WILSON,  
*Secretary of Agriculture.*

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## A METHOD OF BREEDING EARLY COTTON TO ESCAPE BOLL-WEEVIL DAMAGE.

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### INTRODUCTION.

The growing of early and rapid fruiting cotton is most important to escape damage from the boll weevil. This insect, which first appeared in south Texas and rapidly spread north and east, has certain habits in relation to the cotton plant which make the production of early cotton imperative. Weevils do practically no injury to the stem or leaf, only injuring and destroying the young squares or fruit, and in normal seasons most of the adults that survive the winter are out of hibernation at about the time the cotton begins to set squares. Then a race begins between the cotton in setting squares and the weevils in multiplying and destroying the squares. The cotton plant must, therefore, make fruit faster than the weevils can increase in number and destroy it.

The weevil feeds on squares and propagates in them, but does not injure bolls of any size until the squares are nearly all destroyed. The total destruction of squares occurs late in the season, when the weevils are greatly increased in numbers. When this happens the weevils begin feeding upon the youngest or latest bolls, but at this time the older bolls, whether open or not, are safe from injury. Danger to the late bolls increases with the increase in the number of weevils present. The hasty opening of bolls is not an important factor in the crop's escape from weevil damage.

Squares generally fall from the stalk shortly after being punctured, and this removal of the young fruit from slow-fruiting and late-maturing cotton induces under favorable moisture and plant food conditions a prolonging of the vegetative growth and the setting of squares that serve as food and propagating places for an increasing number of weevils to go into hibernation when frost occurs. These habits of the weevil compel cotton growers to plant a cotton that has early and rapid fruiting qualities and the additional quality of maturing the plant as nearly as may be possible under the prevailing soil-moisture and plant-food conditions.

Until the weevil appeared, Texas growers enjoyed a long growing season and generally grew the slow and late maturing cottons. When the rapid spread of the weevil created an urgent and immediate demand for early and rapid fruiting strains, growers were unable to obtain in Texas or from any other source such cottons with other desirable qualities as well, and, moreover, there was an absence of information concerning many features of the cotton plant that affect or were supposed to affect earliness. The growers therefore sought relief from these conditions by importing from the northern and the northeastern edge of the cotton belt thousands of earloads of seed of the small-boll early-opening cotton. This imported seed being non-stormproof and of inferior staple qualities was wholly unsuited to Texas conditions.

Before any cotton-breeding investigations were begun it was generally believed that a large-boll cotton, such as the native Texas cottons, could not be grown early enough to escape the weevil. Likewise it was believed that good staple cotton could not be early. It was a question, also, whether early qualities in cottons could be maintained in Texas with its long seasons, and whether new seed would have to be frequently imported; also, whether northern seed was earlier than southern seed. Such were the conditions and some of the questions before cotton growers in Texas four years ago.

In 1904 the writer began cotton-breeding investigations and cotton breeding in Texas under the first Congressional appropriation for boll-weevil work. At the end of the first season's work, in September, 1904, a statement of results of the investigations was published for the information of growers in selecting seed for the next crop. The results were to the effect that Texas cotton growers need not import early cotton to escape weevils. The investigations showed that early cottons of superior quality could be obtained from native big-boll, good staple Texas cottons on any grower's farm by selecting seed from plants of a type that could be recognized by certain distinguishing characters, which were described in the press reports. A report was also issued in a bulletin in October, 1904. At the close of the next or second season's investigation, 1905, press reports were made and a second brief bulletin issued on the results of the second season's work.

The results of four years' investigations are now completed, and early cottons have been bred and the method for seed selection developed. The results of this work show that growers may by seed selection develop or maintain early fruiting, rapid fruiting, and productiveness in their cotton to escape weevils, and that the method of seed selection for developing such qualities in the cotton plant is easy and inexpensive in practice. One selection rightly made from

the proper type of plant increases earliness and productiveness to a surprising extent. The method may be employed to the greatest advantage by growers east of Texas before the weevil arrives in that section—and that it will go farther east there is no doubt since it is making advances annually. Growers immediately east of Texas are urged, therefore, to practice the method of seed selection herein described and save themselves losses such as the Texas growers sustained when the weevil was advancing through Texas. They may also save themselves the expense of importing seed when the weevil does arrive.

In reporting the results of the work the discussion of details that are familiar to cotton growers is omitted in order to restrict the bulletin to reasonable length.

### THE DISTINGUISHING CHARACTERS OF PLANTS OF EARLY AND RAPID FRUITING COTTON.

“Early cottons” and “earliness” were the terms used almost exclusively to describe plants that opened their bolls early, or that opened before frost or before other cottons. The other cottons were called “late,” since they opened so late that they were in danger of frost. But a different meaning must be given to “earliness” when the boll weevil is considered. The insect shortens the season for making or maturing fruit, but this fact does not require, as has been previously explained, that the bolls should open early to escape damage. Owing to the habits of the weevil the plant must begin to set fruit early and set it rapidly, and this is the meaning of the term “early cotton” as used in this bulletin.

The cotton plant is made up of a main stem, wood or primary limbs, fruit limbs, leaves, and fruit. The main stem and the wood and fruit branches are divided into joints, or nodes. At each joint a leaf is formed, and at each joint on the fruit limbs fruit is set.



FIG. 1.—An early, rapid-fruited, productive type of cotton plant, with low fruit limbs, short joints, and continuous-growing, long fruit limbs. (Leaves removed.)



In studying the many plants of all standard varieties and of nameless cottons it was observed in these investigations that the plants that set fruit early had low fruit limbs—that is, sent out the first fruit limbs at the joint nearest the seed-leaf joint. Figures 1, 2, and 3 show plants with low fruit limbs, while late fruiting plants are shown in figures 4, 5, 6, and 7.

It was also observed that the plants that set fruit rapidly (that is, set much fruit in a short period of time) had short joints or internodes in the main stem and fruit limbs. Figures 1, 2, and 3 show short-jointed plants, while figures 4, 5, 6, and 7 show long-jointed plants.

The short-jointed plants with low fruit limbs grew as fast during the first part of the growing season as the long-jointed plants, and in

the same period of time set many more squares. This equal growth continued until considerable seed began to form in the lower or oldest fruits. Then as the reproductive process increased in the short-jointed or more fruitful plants their rate of growth fell behind that of the long-jointed plants. The powers of short-jointed plants are at this stage devoted more largely to the growth of seed, while the long-jointed plants are making few seeds and hence continue a more rapid vegetative growth provided soil water is sufficient, which sometimes is not the case. About this time the weevils become so numerous as to destroy the squares as fast as

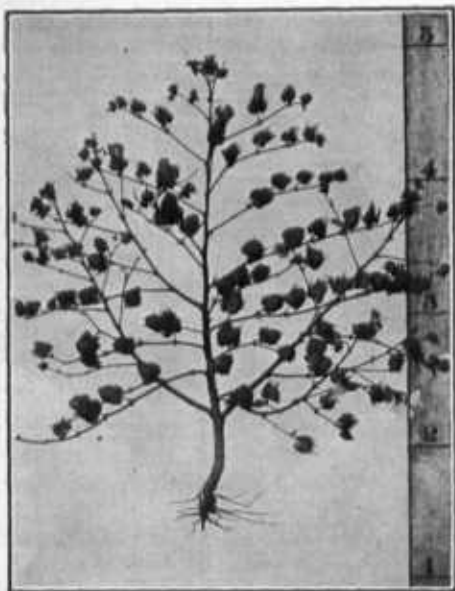


FIG. 2.—Another early, rapid-fruited, productive type of cotton plant, having characters similar to those shown in figure 1. (Leaves removed.)

set on both types of plants, and the short-jointed plant matures its larger crop of squares that are already set, whereas the long-jointed plants, having set but few squares, mature but little fruit, although they may continue to grow.

Previous to the weevil's shortening of the fruiting season the long-jointed plants made in the long season a good yield, since they had time to increase the number of joints and the fruit by growing to a large size, but with the weevil these late plants fruit rapidly at the wrong end of the season. Rapid fruiting must begin at the first

part of the growing season at the base of the plant and not at the latter part of the season at the top of the plant.

The rate of growth is very important for the rapid setting of fruit, and as some individual plants of either the long-jointed or short-jointed types grow faster than other plants of the respective types it is important to select seed from the largest plants of the character or type desired.

Another important character of early rapid-fruited plants was found, namely, the continuous growing of the fruit limbs. This feature is of great importance for a maximum production in a short time. The terminal bud of the first fruit limb and of all subsequent fruit limbs should continue to grow and set squares, or fruit, until the entire plant ceases to grow. With fruit limbs of such a character the main stem may not grow so tall, but the continuous-growing fruit limbs make more fruit early in the lower part of the plant than either a determinate or cluster fruit-limb type. (Fig. 8.) Where there are weevils, continuous-growing fruit limbs are a great advantage in making a large quantity of early fruit. The quality has still another advantage as regards this insect, namely, the weevil seems instinctively to feed on the squares higher up the plant and thereby very often allows late-set squares to make bolls on the lowest continuous-growing fruit limbs. The continuous-growing fruit-limb type is shown in figures 1, 2, and 3. The short or determinate (or objectionable) fruit-limb type is shown in figure 9. The latter type may set and mature two or four bolls on the lowest or first fruit limbs, whereas the continuous fruit limbs may mature from six to eight or more.



FIG. 3.—A third early, rapid-fruited, productive type of cotton plant, having characters similar to those shown in figures 1 and 2. (Leaves removed.)

The low first fruit limbs and short joints and the continuous fruit limbs which were first described by the writer in the press in September, 1904, and later, in October, 1904, in a bulletin, as a guide in seed selection, are distinguishing characters of early rapid-fruited cotton plants. By these characters the grower can distinguish early and rapid-fruited plants, and in selecting plants for seed he may select them at any time after fruiting has well begun or may delay selection until all bolls are open.

A medium-sized leaf, about 6 inches across at right angles to the midrib, is as large as a leaf should be for upland soil. Larger leaves mean too great vegetative vigor, and they prevent in large plants the sunlight from reaching the lowest bolls and opening them. A still smaller leaf, 4 to 5 inches across the midrib, is shown in figure 10. This is a desirable size for deep, fertile bottom soil, where still less vegetative growth and the admission of more sunlight at the base of the plant are desirable. An undesirable large leaf is shown in figure 11.

#### THE INDIVIDUAL COTTON PLANT AND ITS PROGENY.

The cotton plant in seed selection was studied with respect to its features as an individual and not considered as a variety.

Its economic features are seed and lint, and the production of these in the greatest quantity is the desire of the grower. Other features that affect the economic characters are the size of the boll, the size of the leaf, the structure of the stalk as regards the length of the joint, the fruit limbs, and the wood limbs. All of these features vary in degree in the progeny of different plants, but each plant, as shown in these investigations, transmits its features to its progeny with certainty and uniformity, except the variation in certain individual plants due to natural causes and to crossing by insects. This



FIG. 4.—A late, slow-fruitletting, unproductive type of cotton plant, with high fruit limbs and long joints. (Leaves removed.)

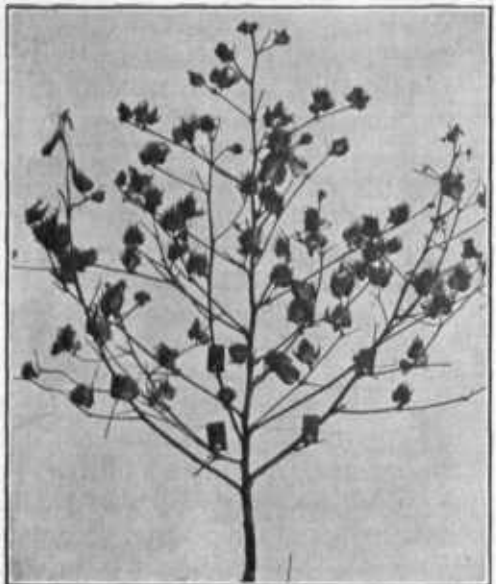


FIG. 5.—Another late, slow-fruitletting, unproductive type of cotton plant, with characters similar to those shown in figure 4. (Leaves removed.)

uniformity is a most fortunate fact, since it enables growers to obtain in a marked degree by one seed selection the qualities of early and rapid fruiting and maturity of plants necessary for escaping boll weevils. Any crossing that may vary the progeny is perhaps caused entirely by insects and is of little or no consequence within the type in general farm selection.

In this work some hundreds of plants were selected and the seed of each mother plant was planted separately in a single row of one-fiftieth of an acre, with equal spacing and similar treatment for all rows. The plants in each row were uniform in appearance. The variation in the rows may be seen in figure 12, which shows rows differing distinctly

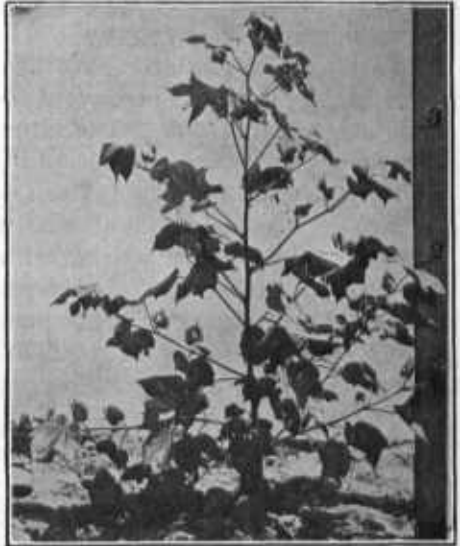


FIG. 6.—A third late, slow-fruitletting, unproductive type of cotton plant, with characters similar to those shown in figures 4 and 5.



FIG. 7.—A fourth late, slow-fruitletting, unproductive type of cotton plant, with characters similar to those shown in figures 4, 5, and 6. (Leaves removed.)

in the time of maturing. In like manner the rows differed in the time of opening their ripened bolls and in the yield of seed cotton, as is shown by the one-half acre of rows reported upon in Table I, page 12. The planting was done between April 10 and 13, and the first picking took place on September 7, 1906.

When the seeds were planted from these first-year progeny rows they made plants of the second year like their parents, thus showing that the plants continue to breed true to their type.

The character of productiveness of fruit in the parent plant appeared uniformly in the second-year progeny. The seed of plants selected for short joints produced like characters in the

and early maturity of the plants

second-year progeny. The progeny of plants of long-jointed, slow-fruited, unproductive types was also uniform in likeness to the parents, as is shown in figure 13. The plant illustrated is two generations from an unproductive mother plant and grew in a row near and is of the same age as the plant shown in figure 2, which is a short-jointed productive type. The latter is the second generation from a short-jointed parent. Hitherto it has been generally believed that soil water controlled the length of joint, but these results show that heredity mainly controls, and that where water affects the length it affects similarly the long-jointed and the short-jointed types of plants. The first and second progeny resembled the seed parent, whether short jointed or long jointed. Low fruit limbs at joints nearest in number of joints to the seed-leaf joint, a very important quality, appear uniformly in the progeny.

TABLE I.—Yield of progeny rows of cotton plants in selection tests covering one-fiftieth of an acre each.

Number of row.	Average height.	Yield at first picking.	Yield at second picking.	Total yield.
	<i>Feet.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
39 .....	2½	27½	6	33½
4 .....	3	31	4	35
37 .....	3	28	4½	32½
8 .....	3½	34	5	39
10 .....	2½	32	4	36
21 .....	3½	33	6	39
32 .....	3½	32	8	40
67 .....	3½	25	11	36
65 .....	2½	30	3	33
100 .....	3½	26	10	36
124 .....	3	31	8	39
131 .....	3½	26	14	40
88 .....	4½	24	14	38
98 .....	4	26	15	41
129 .....	2½	28	3½	31½
52 .....	3	27	7	34
55 .....	2½	24	¾	24¾
47 .....	3½	33	12	45
21 .....	3½	31	5	36
118 .....	4	29	12	41
135 .....	3½	30	9	39
108 .....	3½	37	7	44
127 .....	3½	28	9	37
8 L .....	3½	22	15	37
17 L .....	3½	27	13	40
Yield on the half acre .....				927
Yield to the acre .....				1,854

The continuous growth of the fruit limbs, also an important quality, is uniformly present in the product of such a mother or seed plant. This uniformity of transmission is likewise constant as regards such qualities as the length of staple, size of boll, number of locks, and percentage of lint. Each of these features costs nothing in itself, yet adds profit to the crop.

The number of locks in a boll, however, does not always appear to be the same as in the parent plants. The variation from five-lock bolls in the parents to four-lock bolls in some cases in the progeny plants may be due to seasonal influences, since the progeny seed

may the following season produce almost exclusively five-lock bolls. The same seasonal variation occurs in the percentage of lint to seed. These seasonal variations, however, do not affect the general increase by seed selection of five-lock bolls, the percentage of lint, or the transmission of such qualities to the progeny.

The uniformity of progeny in resemblance to the parent has been the favoring factor in the introduction of the large number of varieties of American Upland cotton, many of which have no merit or excuse for having been produced, the feature distinguishing them from other varieties being often some unimportant detail in appearance of leaf or in a determinate or cluster character of fruit limb.

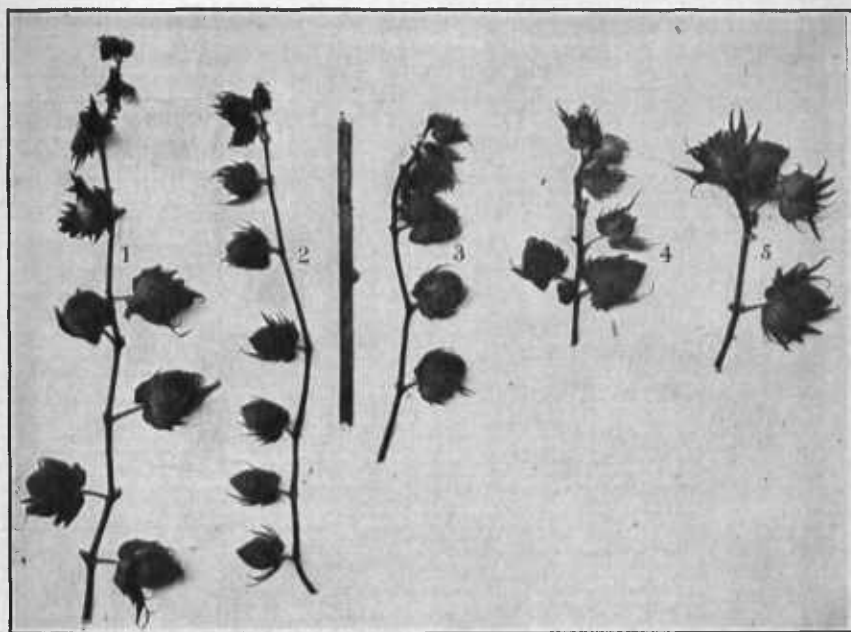


FIG. 8.—Big-boll (1) and small-boll (2) continuous-growing fruit limbs and short determinate (3 and 4) and cluster (5) types of fruit limbs.

The uniform transmission of characters is of the greatest importance to the general cotton grower, because it assures him that by one seed selection he can largely increase the desirable qualities of his cotton.

#### THE TYPE RECOMMENDED FOR EARLY, RAPID FRUITING, AND FOR PRODUCTIVENESS TO ESCAPE WEEVILS.

The type wanted must be clear in the mind of the grower in order that he may recognize the most perfect plants of the desired type

when searching for them in his field or seed patch. From the description previously given of the distinguishing characteristics of an early, rapid-fruited, productive cotton, it is easy to state the type in specific terms.

(1) The first fruit limb must be low, not higher than the fifth or sixth joint above the seed-leaf joint.

(2) The wood or primary limbs must be low, and it is desirable that they should not exceed four in number. The first limb should not be higher than the fifth or sixth joint above the seed-leaf joint.

(3) The joints in the main stem, in the fruit limbs, and in the primary limbs must be short, not exceeding 1 to 3 inches in the lower part of the plant.

(4) Fruit limbs should grow at the successive joints of both the main stem and the wood limbs.

(5) Fruit limbs should be continuous in growth for continuous fruiting until the plant is matured.

(6) The largest leaves should not be wider than 5 or 6 inches across at right angles to the midrib.

Other qualities which do not affect early and rapid fruiting, but which add greatly to the profits of the crop, are size of boll, percentage of lint, length of fiber, and storm resistance.

Picking can be done more rapidly and less trash will be gathered with the cotton when the boll is large. Large

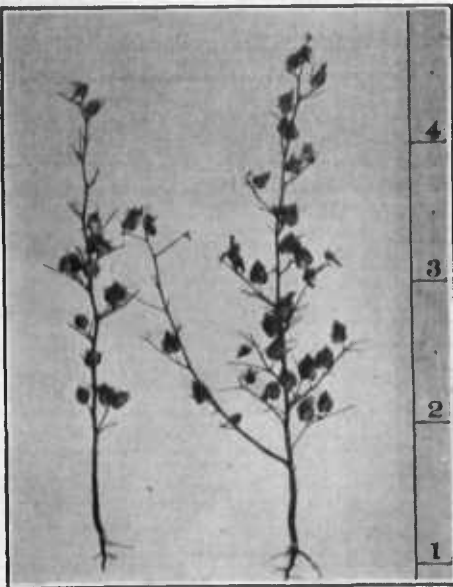


FIG. 9.—A short, determinate fruit limb type of cotton plant. (Leaves removed.)

bolls are also storm resisting, since the boll covering is thick and does not curve backward in drying and leave the locks unsupported (figs. 14 and 15).

A cotton should yield as large a percentage of lint as possible. About 38 per cent is the general yield of the few varieties that give the highest percentage. The proportion of lint, however, seems to vary more or less with the season. By selecting for lint, as much as 40 per cent may be made to grow regularly and on a seed of good size and in a large boll.



The fiber should not be less than an inch long, and this length is sufficient for general purposes. For special purposes of finer manufacture longer fiber is required, but the quantity called for is relatively small as compared with the total requirement for 1-inch staple. Fiber much shorter than 1 inch can be and is used; but were there much of such short staple its value relative to that of 1-inch staple would be less than is ordinarily the case.

The leaf has no market value, but if too large—more than 6 inches across at right angles to the midrib in



FIG. 10.—A small-leaf type of cotton plant.

the largest leaves—it prevents the drying of the lower bolls and, where the plant is large, causes the loss of bolls by rotting.

The type of which the foregoing is a description is shown in figures 1, 2, and 3.

As before explained and as may be seen in Table I, the opening of the bolls of one plant earlier than those of another does not indicate superiority in escaping weevils. The weevil stops all



FIG. 11.—A very large leaf type of cotton plant.

plants from fruiting at the same time, and the cotton which yields



the most is the one that best escapes the weevil, regardless of the date of opening. Large-boll cottons rarely begin to open as early as some



FIG. 12.—Progeny rows showing defoliate and foliate rows of early rapid-fruiting types of cotton.

small-boll cottons, though both begin setting fruit at the same time. But notwithstanding the few days' delay which may occur in



FIG. 13.—Cotton plant bred for unproductiveness and late fruiting. (Leaves removed.)

the opening of the large bolls, some large-boll progeny rows in our experiments yielded more cotton than the small-boll early-opening progeny rows. (Compare rows 8 L and 17 L with rows numbered 129 and 55 in Table I.) This point as to the opening of bolls is specially emphasized and explained because a large boll is more desirable for many reasons than a small-boll cotton and is preferred by growers and pickers. The belief was quite general when this work began that the opening of bolls even a few days earlier than those of other varieties was of importance in escaping weevils,

and as the earliest opening cottons at that time had small bolls and the old late cotton had large bolls, the conclusion was reached that a large-boll cotton could not be grown

to yield successfully where there were weevils. Moreover, it was thought that the simultaneous setting of squares on different cottons should be followed by the simultaneous opening of their bolls. A similar belief equally erroneous would be that cottons setting squares at the same time should have bolls of the same size, shape, etc. The most successful escape from weevils is indicated by yield and not by the date of the first open boll or by greater yield at the first picking, and large-boll cottons have been bred in this work to fruit early and rapidly and to escape weevil damage as successfully as any small-boll cotton that opens all its bolls ten days or two weeks earlier.

### **SEED SELECTION FOR EARLY, RAPID FRUITING, AND FOR PRODUCTIVENESS TO ESCAPE WEEVILS.**

Seed selection is generally believed to be a long process, one where a little progress toward improvement is made each year and in the course of several years the desired result may be obtained. This breeding work with cotton has shown that in the first selection from the right type of plants a marked increase can be secured in early fruiting, rapid fruiting, and productiveness, combined with good-sized bolls, a good average percentage of lint, and a good length of staple. If growers wish to develop such qualities or to maintain them in a cotton they can do so by pursuing the method of seed selection here recommended. They can by one year's selection largely increase the early, rapid-fruited qualities in a cotton and obtain a crop that will successfully escape serious weevil damage.

For the best results a grower should make his selections from a cotton that conforms nearest to the type for boll-weevil conditions. There are many varieties that are far from this type, and to begin selection from them would be a decided disadvantage. Texas growers prefer a large-boll cotton, 50 to 60 bolls to a pound. The bolls of many varieties are so small that it takes 90 of them to yield a pound of cotton (fig. 16) and picking is necessarily slow.

There is a disposition on the part of many growers to judge the yielding quality by the eye when all the bolls are open. This practice is extremely deceptive with a small-boll small-leaf cotton as compared with a large-boll medium-leaf cotton. The latter shows less bolls than it really has because of its larger leaf, and it may have fewer bolls but exceed the yield of the smaller boll cotton. Only with scales can a considerable difference in yield be determined.

After all bolls are open, the stalks of the type are selected and all the largest bolls around the center of the stalk should be picked for seed. All bolls at the top and ends of the limb, whether open or not, may be rejected—perhaps about one-third of all the bolls—only about

two-thirds being picked. Around the center of the plant the most perfectly matured and largest bolls are grown, and their seeds are heavy, well developed, and well matured. In rejecting the smaller and defective bolls all weak and light seeds are excluded. Where growers plant seed from the first picking of all bolls without any selection as to either plants or bolls, they get seed from all kinds of stalks and bolls, and get heavy and light seed, making

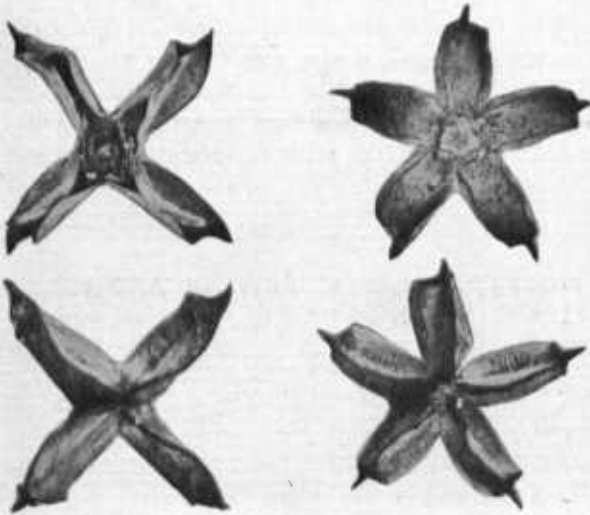


FIG. 14.—Small non-stormproof, open cotton bolls.

an average grade of seed and an average yield.

Growers generally consider seed selection a heavy task, and it would be so if enough seed were carefully selected to plant a grower's entire crop, but selection on a large scale is unnecessary. A grower cultivating 50 acres of cotton and planting 1 bushel of seed to the acre, which is the quantity generally used, would require 50 bushels of seed. This quantity of seed should be grown on a seed patch, which should be made to produce as much as three-fourths of a bale to the acre, by using either good soil or fertilizer. Thus 1,200 pounds of seed cotton would yield 800 pounds of

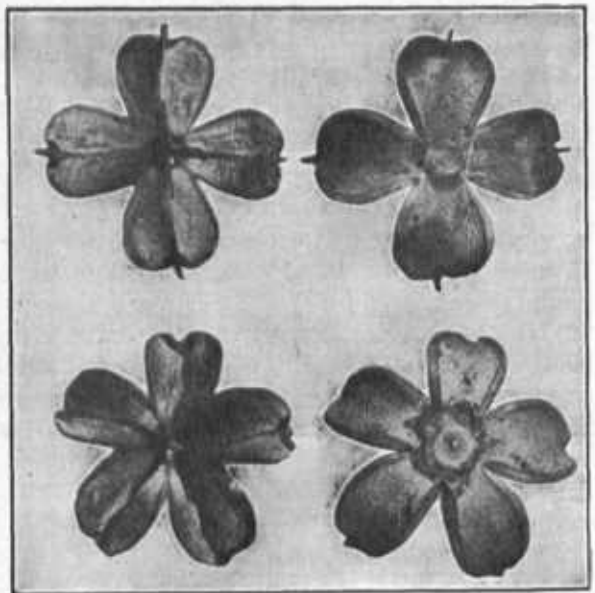


FIG. 15.—Large, thick, stormproof, open cotton bolls.

seed, and by picking only two-thirds of the crop for seed the yield would be 533 pounds, or 18 bushels of planting seed to the acre.

A seed patch of only 3 acres would make 54 bushels, or 4 bushels more than enough to plant a grower's 50 acres of general crop. To search carefully for enough type plants to plant the 3-acre seed patch is a small task. One peck of seed to the acre is enough, and 24 pounds, or 3 pecks of seed, represent 36 pounds of seed cotton to be picked from type plants. Should the type plants yield one-fifth or one-fourth pound each, it would mean finding and picking 180

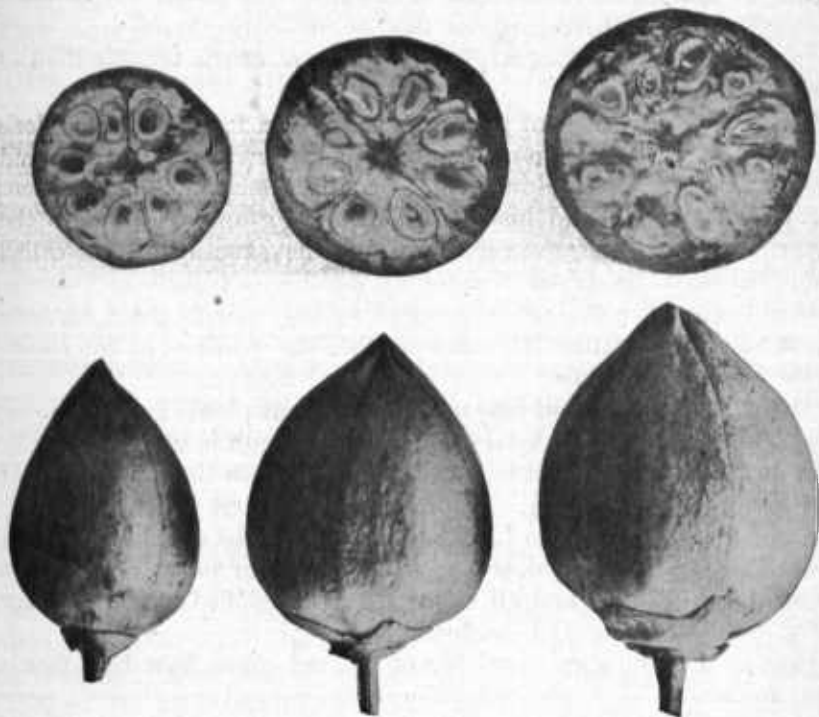


FIG. 16.—Cotton bolls showing distinct differences in size. Large boll on right, 40 to the pound; medium boll in center; small boll on left, 90 to the pound.

or 144 type plants. The first year's selection of the 200 type plants could be made from the general crop, and selections after the first year would be from the 3-acre seed patch. After selecting and picking enough type plants to plant the seed patch, two-thirds of the remainder is picked to plant the general crop. Should a grower cultivate 100 acres a 6-acre seed patch would be needed.

In general seed selection the plants may be selected and picked together and not kept and planted separately, but where the grower is disposed to give the necessary time and care to the matter the

seed of each of the 200 or 300 type plants may be planted in separate rows to determine through the progeny the individual plant that has the greatest producing power. In this case the seed patch is not planted until the second year, and it is then planted with the seed of the row that produced the most cotton. The producing power of the mother plants varies, as shown in the yield of progeny rows in Table I, but growers will get increased earliness and productiveness by one selection of seed plants without growing them separately. Owing to the details and care involved in determining the producing power of individual plants and in breeding for longer staple, finer quality, and high percentage of lint, on the other hand, such work is specialized and is more within the province of the breeder than of the general grower.

The usual description of planting seed offered for sale is the seller's assertion that the cotton made three bales or more per acre and that it is the best cotton on earth. Usually the seller's qualifications for judging cotton and his financial standing are unknown to the buyer. Many cotton growers have become skeptical of so-called improved seed, doubtless because of purchases from such sources. Where the grower finds it convenient to buy seed to plant his seed patch he should require the seller to state the qualities of the cotton in the terms of the type.

The size or diameter of boll in type or parent plants is easily measured by a caliper rule. A very sharp pointed boll is objectionable in picking, and a very round boll contains less cotton than an elongated boll of the same diameter. The height of the first fruit limb above the seed leaf joint and the fact that the fruit limbs are continuous in growth should be determined; also the length of joints of the fruit limbs and main stem and all other features specified in the type for early, rapid fruiting and productiveness.

Most of the long-staple varieties of Upland cotton have been developed for length of staple, and little attention has been given to early and rapid fruiting or to increasing the percentage of lint, but each of these qualities may be increased in long-staple cottons by seed selection from individual plants that have these qualities most highly developed.

Deterioration of the qualities in cotton comes about through non-selection of seed. Where seed selection is not pursued, the planting seed comes from both good and poor stalks, from immature, diseased, and insect-injured bolls, and from plants resulting from the crossing of good and poor varieties by insects.

If seed selection is not persisted in, high-grade seed will quickly deteriorate in productiveness and in other qualities. Failure to select

seed accounts for the common complaint among growers that even seed that is very productive for the first few seasons soon declines.

### **EARLY AND RAPID FRUITING MEASURED BY THE YIELD OF THE SELECTIONS IN THE BOLL-WEEVIL DISTRICT.**

After the type for early and rapid fruiting was determined in 1904, many individual plants conforming to this type were selected from a common Texas cotton, the name and history of which could not be learned. Its earliness and productiveness were above the average. Dr. J. H. Wilson, of Quanah, Tex., secured the seed in compliance with the request of the writer for a supply of seed of common Texas cotton. The results with a half acre of progeny rows planted with seed of parent plants are reported in Table J. The average yield to the acre of the progeny rows was 1,854 pounds, while the yield of Quanah common seed was 1,630 pounds. The gain in yield per acre was therefore 224 pounds.

The seed of the best yielding progeny rows was planted in 1907, and the plants were true to the type and characters of the parent progeny rows and to the original parent plant of each. The selections included parent plants of small, medium, and large boll types. Early, rapid-fruited defoliate strains with medium bolls and early, rapid-fruited nondefoliate strains with large bolls have been developed in this breeding work. Cottons for best results on very different soils and climates must be bred and developed on soil typical of the region where they are to be grown.

### **EARLY-MATURING DEFOLIATE COTTON.**

In this work of breeding early cottons some strains matured their plants extremely early and shed their foliage a considerable time before frost. Two strains of this character, defoliates, are exhibited in figure 12. See also Table I, Nos. 65, 129, 39, and 55. These cottons deprive weevils of food and places for propagation and under certain conditions reduce the number of weevils at the latter end of the growing season which will go into hibernation and appear the next season.

This character at first seemed to offer useful possibilities in this respect, but in order for it to be effective the time between the maturity of the plants and the first frost must be sufficient to decrease the number of weevils by starvation and to prevent their propagation. The length of the growing season is not the same throughout the cotton belt or in the same place in all seasons, and therefore the period of fruiting of this cotton would of necessity

have to be shorter in some sections or seasons than in others. Furthermore, such cottons, to be effective as regards the weevil, must have a limited period for making fruit, and as the seasons are not of the same length in different parts of the cotton belt and as climatic conditions prevent the weevils from being as numerous in some years as in others it is the conclusion of the writer, after developing and growing cottons of short and of long fruiting periods, that a cotton with a short fruiting period will not yield any more when weevils are numerous and will yield less when weevils are not numerous than a cotton with a longer fruiting period. Were there no winter season in the American cotton district to reduce the weevils, these very early maturing defoliate cottons would perhaps be of essential importance in reducing them.

Variation in rainfall and the occurrence of drought, high heat, a late spring, and early frost, together with irregular and indifferent planting and cultivation, are conditions that largely affect the crop. A cotton plant to yield a maximum amount under such varying conditions must not have a short and fixed fruiting period, but must begin fruiting early in the season of growth and must fruit rapidly and continue to set fruit until its growth and fruiting are brought to a close, as they will be when the weather conditions and length of season are normal by its inherent tendency to mature under the influence of its strong reproductive process acting upon the vegetative process and also by the influence of high heat and decreasing moisture. This early, rapid-fruited cotton when planted early comes to some degree of maturity every season, but the degree of maturity varies with the time of planting and the climatic conditions that prevail toward the close of the growing season. It deprives the weevil under normal conditions of both food and squares to some extent and yet makes a maximum yield under the varying conditions. The early, rapid-fruited, defoliate cotton yielded as much in 1907 when weevils were very numerous as the early, rapid-fruited, nondefoliate or persistent fruited cotton, but the latter yielded more in 1906 when weevils were not so numerous. The early-maturing defoliate Nos. 39, 65, 129, and 55 grew smaller, as may be seen in Table I, and yielded well, but produced less in 1906 than those progeny rows that were a little later in maturing. The latter never completely defoliate, but they practically stop growing and making squares before frost when planted early on upland at the place where developed, College Station, Tex. The indifferent planting and cultivation practiced on many farms would be more harmful to short-fruited cotton than to longer fruited cotton. The long-fruited period of the cotton plant is the factor that has for all time enabled every degree of poor farming to produce cotton.



## RESTRAINING RANK VEGETATIVE GROWTH BY SEED SELECTION.

On rich bottom land, growers have trouble on account of their cottons growing too rank or large. The lower bolls rot more or less and the plants grow out of all proportion to their yield. Seed selection was made to determine what could be done to restrain the size of plants. The selections were made in the King and Jones varieties and in an unknown variety. These cottons were growing on very rich river bottom land and the stalks were 7 to 9 feet tall. By careful search small plants were found of the King and Jones varieties, from  $2\frac{1}{2}$  to 3 feet in height and very full of open bolls. In the unknown variety there was very little difference in the height of the plants and no very small plants could be found.

Seeds were taken from the very small and from the large plants and in the following spring they were planted on bottom land and on hill land. The stand on the bottom land was destroyed by unfavorable weather, but the planting on the hill land or upland grew and exhibited the characters of the parents. The progeny of the small King plants grew to be 2 feet tall. The progeny of the large King plants grew to  $3\frac{1}{4}$  feet tall. The progeny of the Jones variety from small plants grew to  $2\frac{1}{4}$  feet tall and from large plants to  $3\frac{1}{4}$  feet. The progeny of the unknown variety, in which no small plants were found, exhibited little difference in height. This lack of difference in the height of the progeny was in conformity with the parents of the unknown variety. In the King and Jones varieties the small progeny plants were more fruitful than the large ones. The latter had very long joints.

These differences in the progenies would undoubtedly have been greater if the plants had grown on bottom land. The conditions there would have favored and continued the strong vegetative growth of the large plants.

Growers may by seed selection limit the size of their plants either on bottom land or upland, and in doing so make them more fruitful. The selection must be from very small and fruitful plants.

## CROSSING OR HYBRIDIZING.

Crossing is not difficult, though it is sometimes so regarded. Some growers have thought crossing to be the first essential to the improvement of the economic qualities of a staple crop, such as cotton. Crossing one plant with another is accomplished by simply transferring pollen of the flower of one plant to the receptive stigma of the flower of another plant after having first removed the pollen of the latter, if a self-fertile flower, to prevent its fertilizing the stigma. The flower is then covered to prevent fertilization from other sources. Cross-



ing is practiced when it is desirable to add one quality or character of the plant of one variety to another or to make a new type with new combinations of characters or to increase vigor and productiveness. In the Upland cotton plant, where early and rapid fruiting and productiveness are wanted to escape the weevil, the grower need not concern himself with crossing. These qualities can be had by pursuing the method of seed selection described in this bulletin. The desired qualities in marked degree can be secured in one selection. If all the cotton growers in the South would follow this method of seed selection the increased yield of American cotton would be 10, and more likely 20, per cent.

### **TREATMENT TO INSURE A STAND OF EARLY-PLANTED COTTON.**

Next in importance to early and rapid fruiting seed to escape weevil damage are early planting and an early stand. Every day of delay in planting after the earliest possible time to plant lessens the yield, especially in years when weevils are present in great numbers. The reduced cotton crop in Texas in 1907 was mainly due to failure and repeated failure to get or to keep a stand of cotton. The final planting that made the crop in a large part of the State was so late that the plants had but little time in which to make fruit before the weevils, which were favored by a very mild winter, became too numerous for the plants to fruit longer. Had growers succeeded in getting and keeping an early stand, a normal yield would undoubtedly have been obtained. The growers sustained a loss in the yield and a loss in replanting, besides paying the increased cost of cleaning the soil, which became very foul from delay of cultivation while waiting for seed to germinate a second and, in some localities, even a third time.

An early stand is so essential to a full crop and low cost of production that growers need to begin preparing the seed bed as soon as picking is finished in the autumn. As winter rain is not always certain in Texas, early bedding is advisable in order that if there be any rain it will make firm the seed beds, which is one essential in getting and keeping an early stand. Securing an early stand, however, is generally regarded as difficult and uncertain. It is only certain when every condition is just right, but as often as otherwise the conditions are just wrong. Especially is a stand uncertain when rain and cold occur after planting, and these almost invariably occur to some extent when the planting is early.

To determine the treatment necessary to assure a stand in planting early under adverse weather conditions, many observations and experiments were made in planting during the four years of this breed-

ing work, and as a result it is confidently believed that there need be no uncertainty in any season in either getting or keeping a stand in early planting. Growers are urged to follow the suggestions and practice the method of planting shown to be the best by experiments. This course will assure a stand, which is essential to escape weevils and bollworms and to make a full yield.

#### **FAILURE OF EARLY-PLANTED SEED TO COME UP CAUSED BY DEEP COVERING.**

In the investigations referred to it was found that when good seed planted early failed to come up the failure was due to the depth of planting or to covering the seed too deeply. When early-planted seeds were covered more than an inch and rain and cold—not frost—followed, they failed to come up, although in some instances they had germinated, but when good seeds were planted early and covered very shallow, less than an inch, the stand came and remained regardless of rain and cold weather after planting.

Shallow covering is absolutely essential when planting is done very early, and the depth of covering should be less than an inch. Seeds planted shallow and covered less than an inch are warmed by the sun, and the air takes away surplus soil water, whereas when covered deeply they are not warmed by the limited heat of the sun of the early season and a rainfall followed by cold destroys them. The seed must be scarcely covered.

#### **COTTON DYING AFTER COMING UP.**

The weather immediately following early planting may not be too cold and wet for the stand to come up when the seeds are planted the ordinary way and covered deeply, but cotton often dies after coming up, especially when the weather is wet and cold. This appears to be due chiefly to the fact that the young plants have largely exhausted themselves in coming through the deep covering.

When the soil is not warm, more time is required for the young plants to come through the covering of earth, and the delay and extra energy that they have to expend in coming through the heavy covering exhausts them, they are more subject to damping-off, and in cold weather they frequently die. When the seeds are lightly covered and planted in the right way little time or energy is consumed by the plants in coming up. They are virtually up all the time.

A stand of early-planted cotton may be lost by long-continued unfavorable weather conditions. In such a case the stand can be strengthened and maintained by shallow cultivation of the beds while the cotton is coming up and by frequent cultivation thereafter

if the moisture or rainfall permits. This treatment when it can be given dries and opens the soil, admits air and warmth, and aids the cotton in its resisting power and in growth until the weather conditions become more favorable. A light wood-frame side harrow, weighing not over 35 pounds, with either "duck foot" or plain harrow steel teeth, is the best tool.

When the seeds are planted in a sweep furrow the stand of young cotton is often lost in a wet, cold spring on account of the lack of drainage. This is especially true in sandy soils.

#### SOME EXPERIMENTS AND OBSERVATIONS.

On March 20, 1906, 20 acres were planted with nearly a bushel of seed to the acre, the seed being covered with about 2 inches of soil. As the soil was warm germination began very promptly, but a moderately heavy rainfall, followed by a few days of cold weather, destroyed all the seed in the soil.

On April 10, 1906, these 20 acres were replanted at the rate of 1 peck to the acre, the seed being covered from one-half to three-fourths of an inch, and at the same time 6 acres were planted and the seed covered about 2 inches. A stand was obtained on the 20 acres where the seed was lightly covered, while not so good a stand came on the 6 acres, but no cold, wet weather followed these plantings to affect the seed which was covered 2 inches.

The month of April, 1907, was colder than March, and in the first week of April 20 acres were planted at the rate of 4 pounds of seed to the acre. A good planter was used, and the covering was not over three-fourths of an inch in depth. All the seed came up and lived. In 1906, some of this land was in sorghum, some in corn, and some in cotton. The roughest of the land was the corn land, and because of its open nature, due to stalks and grass and the absence of winter rains, some of the young cotton plants died, their roots not being able to come in contact with firm soil. Where the seed bed was firm none of the plants died. This experience shows the importance of a firm seed bed.

On 3 acres of land selected seeds were hand-dropped in 1907, one seed every 3 feet, and scarcely covered. All the seeds came up except where occasionally a seed was covered too deeply. This planting on April 12 was followed by two weeks of cold and rain that would have prevented deeper covered seed from coming up.

There is generally more moisture in the soil to germinate and bring up early-planted seed than there is later in the season, and there would always be sufficient moisture to bring up the early-

planted seed if the soil or beds were harrowed so as to hold moisture and destroy weeds and grass till planting time.

Very little warmth is required to germinate early-planted seed that is lightly covered.

Where the seed bed is not firm it is practically impossible to cover early-planted seed to the right depth. It is also practically impossible to cover early-planted seed to the right depth when the covering is done with small plows on the planter unless they are so constructed as to prevent them from going too deep, an almost impossible thing to do, especially on a one-horse planter.

For growers to carry out successfully these suggestions as to shallow covering and keeping a stand in early planting, three things are necessary:

- (1) The seed bed must be firm and clean.
- (2) The soil of the beds must be harrowed before planting and cultivated shallow while the seeds are coming up, if necessary, and as often thereafter as moisture permits.
- (3) The planter used must be of the right type.

It is necessary to have a gauge wheel in the rear of the planter to regulate the depth of planting and to press the seed into direct contact with the firm under-soil, so that the soil moisture can enter the seed.

All planting seeds should be as free from lint as it is possible to gin them. They can then come in contact with the soil and readily absorb moisture and will germinate more quickly.

These results are given for early planting only and in rainy districts. Late planting is not to be considered in weevil districts and is therefore not discussed.

Seed planted early escapes the heavy packing rains that come later in the season, and when the planting is rightly done a stand is more certain than from late-planted seed.

An early stand of cotton is so important where boll weevils and bollworms are present that a cotton grower can not afford to neglect anything that will aid him in securing and maintaining an early stand.

### SUMMARY.

Productive cotton is important regardless of the weevil, but under weevil conditions the planting of early, rapid-fruited, productive cotton is imperative for the making of a profitable crop. The method of seed selection recommended may be followed by growers outside of the weevil district as well as by those within the infested territory.

By applying this method in selection, slow-growing and unfruitful plants are eliminated and the selected seed will produce an increased yield of seed cotton, an increased proportion of lint to seed, and a better quality of lint or fiber.

The cost to the cotton grower to make a general seed selection and propagate enough seed in a patch to plant 100 acres of general crop will not exceed \$5.

While growers are able to improve their own cotton by applying the method of seed selection described in these pages, yet the recommendation is made that they secure seed from breeders or from other sources whenever seed superior to their own can be obtained.

Early planting is essential to the making of a full crop under boll-weevil conditions, and the treatment recommended for insuring a stand does not require any extra expense. By planting the seed very shallow, less than an inch, on a firm seed bed, an early stand can be secured and maintained.

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